METHOD FOR MANUFACTURING SOLAR CELL AND SOLAR CELL

TECHNICAL FIELD

[0001] The present invention relates to a method for manufacturing a solar cell and a solar cell, and more specifically to a method for manufacturing a solar cell at a low cost with high efficiency, and a solar cell manufactured with this method.

BACKGROUND ART

[0002] Nowadays, how to reduce a cost is an important issue in a method used for manufacturing a solar cell for consumer use. To that end, a method that combines a thermal diffusion method and a screen printing method has been generally employed. A detailed description thereof is given below by way of example.

[0003] First, a single-crystal silicon ingot pulled up with a Czochralski (CZ) method or a polycrystalline silicon ingot manufactured through casting is sliced with a multi-wire process to thereby prepare a p-type silicon substrate. Next, slice damage on the substrate surface is removed with an alkaline solution. After that, the surface is given microscopic unevenness (texture) with the maximum height of about 10 μm, and an n-type diffusion layer is formed by a thermal diffusion method. In addition, TiO_2 or SiN is deposited with a film thickness of about 70 nm on a light-receiving surface to form an anti-reflection film. Next, a material mainly containing aluminum is printed throughout the back side of the light-receiving surface and then subjected to firing to thereby form a back electrode. On the other hand, a light-receiving surface side electrode is formed by printing a material mainly containing silver into a comb-like shape with a width of, for example, about 100 to 200 μm and firing the material.

[0004] This method is advantageous in that various effects that enhance characteristics are concomitantly obtained albeit the minimum necessary number of steps necessary for fabricating a device. For example, the thermal diffusion has an effect of increasing a diffusion length of minority carries in a bulk due to its gettering action. Further, upon firing the aluminum material printed on the back side, a p^+ type high-concentration layer that serves as a BSF (Back Surface Field) layer is formed on the back side together with the electrode. Moreover, the anti-reflection film has an effect of lowering a recombination speed of carriers generated in the vicinity of the silicon surface as well as an optical effect (effect of reducing a reflectivity).

[0005] Owing to the above-described minimum number of steps and several beneficial effects, a cost for a solar cell for consumer use becomes lower than before.

[0006] However, this method could not improve conversion efficiency any more. For example, conversion efficiency of a solar cell using a single-crystal silicon substrate peaks out at about 16%. This is because dopant such as phosphorus in a diffusion layer should have a surface concentration of about 2.0 to 3.0×10^{20} cm^{-2} to minimize a contact resistance of the light-receiving surface side electrode. If the surface concentration is high as above, a surface level becomes very high, so carrier recombination is promoted near the light-receiving surface, a short-circuit current and an open-circuit voltage are limited, and conversion efficiency peaks out.

[0007] To that end, there has been proposed a method of reducing a surface concentration of a diffusion layer at a light-receiving surface to improve conversion efficiency by use of the above method that combines the thermal diffusion method and the screen printing method. For example, the invention pertinent to this method has been known as disclosed in the specification of U.S. Pat. No. 6,180,869. According to this publication, a low ohmic contact can be formed even with the diffusion-layer surface concentration of about 1.0×10^{20} cm^{-2} or lower. This is because a compound containing a dopant is added around a silver filler in an electrode paste. Thus, the dopant forms a high-concentration layer just below the electrode upon firing the electrode.

[0008] However, the above method of adding the dopant-contained compound around the silver filler in the electrode paste involves a problem in that a fill factor is low and reliability is low because a contact cannot be formed with stability.

[0009] Further, "a photoelectric conversion device and a method for manufacturing the same" as disclosed in Japanese Unexamined Patent Application Publication No. 2004-273826 has been known, for example, as a method of forming a high-concentration diffusion layer (emitter layer) containing a dopant in a high concentration only just below an electrode to lower a surface concentration of a diffusion layer in the other region of the light-receiving surface, that is, forming a two-stage emitter structure to improve conversion efficiency. This method is accomplished by changing a known method of forming an electrode in an embedded electrode type solar cell as disclosed in Japanese Unexamined Patent Application Publication Nos. Hei 8-37318 and Hei 8-191152 from electrolytic plating to screen printing. This method facilitates manufacturing control and reduces a manufacturing cost.

[0010] However, this manufacturing method for an embedded electrode type solar cell requires at least two diffusion steps and thus is complicated, resulting in a high cost.

[0011] As another example of the method of forming a two-stage emitter structure to improve conversion efficiency, "a method for manufacturing a solar cell" (Japanese Unexamined Patent Application Publication No. 2004-221149) is known, for instance. Proposed in this publication is that plural types of coating materials are applied by an ink-jet method at the same time to form plural regions containing different kinds of dopants in different dopant concentrations through simple steps.

[0012] However, in the case of manufacturing a solar cell through dopant application with the ink-jet method, if a dopant is a phosphoric acid or the like, it is necessary to take a corrosion countermeasure, so a device is complicated and troublesome maintenance is required.

[0013] Further, as another example of the method of forming a high-concentration diffusion layer only just below an electrode to lower a surface concentration of a diffusion layer in the other regions of a light-receiving surface to increase conversion efficiency, "a method for manufacturing a solar cell" (Japanese Unexamined Patent Application Publication No. 2004-281569) is known, for example.

[0014] However, this method requires two heat treatment steps as described in the specification of Japanese Unexamined Patent Application Publication No. 2004-281569 and thus is not simple. However, if the heat treatment step is performed only once, a dopant concentration is increased even in the regions of the light-receiving surface other than